ICC MIWG: Mobile Displays
17 April 2014 • 16:00 (UK) / 11:00 (EDT)

The meeting was called to order at 11:00 am (EDT) by Craig Revie, chair, with the following attendees:

1. Aldo Badano
2. Vitaly Bondar
3. James Chang
4. John Dalrymple
5. Michael Flynn
6. Olga Konovalova
7. Andy Masia
8. John Penczek
9. Steve Rankin
10. Craig Revie
11. Thomas Schopf
12. John Sweeney
13. Hong Wei
14. Masahiro Yamaguchi

After a check of the sound quality Mr. Revie outlined future meeting plans. Conference call dates have been set for 15 May (Opthalmology, led by Christye Sisson), 17 July (TBD), 18 September (WSI), 18 October (TBD) and 11 December (WSI). He invited any of the activity leaders to use the TBD dates for their activity. The full meeting schedule is at http://www.color.org/groups/medical/medical-meetings.xalter.

There will be topic-oriented meetings at the FDA in June (http://www.color.org/groups/medical/silverspring2014/) and the full ICC MIWG at Boston in November, co-located with CIC (http://imaging.org/ist/conferences/cic/) and IADP (http://imaging.org/ist/conferences/iadp/). Mr Revie showed the call for papers for IADP, which may be of interest to members of the group, and noted that CIC will possibly expand its tutorials to include Digital Pathology. ICC DevCon (http://www.color.org/DevCon/) is also in Boston on November 3.

Mr Revie handed over to Mr Andy Masia, the project leader for Mobile within ICC MIWG, who presented slides [see attached]. Mr Masia noted the previous meeting of this activity had been in Vancouver, and the focus was on mobile displays rather than other issues related to mobile devices in medical imaging, which might include image capture, archives, security etc. Image capture could be handled in the Medical Photography activity led by John Penczek, and the others were out of scope of this activity.

Mr Masia reviewed the agenda, which included the AAPM task force, the limits of mobile colour management, and introductions to vendor products which addressed the problem statement of this activity.

AAPM task force

Dr Aldo Badano reported that a task force had been started in AAPM on viewing medical images on mobile devices. This included topics such as measurement, resolution, noise and artefacts as well as colour. It was recognised that ICC MIWG had expertise on colour management and undertook to coordinate between the two groups.

Limitations of mobile colour management

Mr Masia reported that X-Rite have measured a very large number of colour displays, and the resulting data shows large differences in colour and gray scale rendering, white point and colour rendering characteristics. He anticipated there to be similar variation on mobile devices. There was no standard colour processing architecture (such as ICC colour management) on mobile devices, and the technology used changes rapidly.

Vendor products

Mr Masia gave an overview of the X-Rite Colortrue product, which is now available. A free app can be downloaded that enables a mobile to be measured (with a supported instrument) and makes output profiles that are stored in an appropriate location for iOS and Android. It applies profiles when displaying images, using the input profile embedded in the image as source (or sRGB if no embedded profile) and the Colortrue display profile as destination. Unlike desktop and laptop displays, no calibration of the display is performed since there is no infrastructure to support this on the mobile platform.

Images are viewed in a dedicated Colortrue viewer. X-Rite also provide a freely-licensed SDK to developers to enable integration into other applications.

Mr Masia also showed slides from a Colortrue marketing presentation [see attached]. Since the mobile platform is a reality in medical imaging, it was necessary to make colour work as well as possible. Ideally devices should be able to work in any location, and adjust for ambient illumination conditions as needed.

He compared the colour response of iPad mini, iPad3 and sRGB. The iPad had a smaller gamut, and both devices differed markedly from sRGB in their white point and tone reproduction. The difference was particularly noticeable in shadows, where the flatter tone curve is a significant problem when viewing images with shadow detail, such as X-rays.

Mr. Steve Rankin of X-Rite stated that X-Rite aim to provide a CMM and profile management infrastructure for the mobile platform, which applies profiles in real time. The free SDK enables the technology to be used in other applications. When generating a profile images are captured at all illumination levels and display brightnesses. The current display brightness setting is monitored in real time and the profile rebuilt as needed. On the Android platform, the illumination sensor is used to capture ambient lighting conditions and make adjustments, but on iOS X-Rite did not have permission to do this and so user selection of ambient lighting levels is supported instead.

The aim is to be able to maintain constant image appearance in different conditions, but SDK users are able to choose what aspects they wish to implement.

Mr Masia clarified that X-Rite had considered use of the device's camera to capture ambient light, but this would require a degree of user involvement so had been rejected. The camera capture approach is also very sensitive to the particular field of view including any light sources present.

He also stated that it was possible to render to a colour space such as DICOM, and use this as the source when converting to the PCS using the appropriate input profile, which should result in a DICOM-calibrated image on the display. Some cloud applications strip ICC profiles from images or convert to sRGB, so care needs to be taken in how the images are uploaded to the mobile device.

Dr John Penczek proposed that it would be useful if manufacturers made raw RGB images available to the app to minimise the effect of non-linear processing. This could possibly be taken up in the MIWG Medical Photography activity.

Mr Masia invited the group to download the app, get more information at http://xrite.com/colortrue, and contact Mr Masia amasia@xrite.com with any questions. He also invited the group to evaluate the install Colortrue and use it to view images, and for developers to integrate with their applications to make the 'Colortrue-aware'.

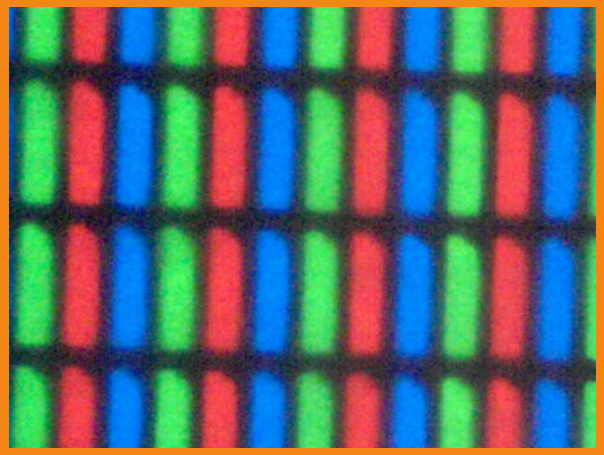
Mr Masia concluded the discussion by showing the 'Next steps ' list from the Vancouver meeting, adding the Colortrue evaluation as a further action.

Mr Revie thanked the participants for attending, gave a reminder of the next telecom on 15 May, and closed the meeting.

Action items:

MIWG-14-27 Coordinate between AAPM task force on mobile imaging and ICC MIWG Mobile activity (Badano)
MIWG-14-28 Evaluate Colortrue app (all interested)

MOBILE FOR MEDICAL



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AGENDA

- AAP TG 260
- Review limitations of mobile platforms relative to color management infrastructure
- Vendor tools presentations
  - X-Rite ColorTRUE
  - Others
- Next steps

AAPM TG 260

- **Considerations for the Use of Handheld Devices for Viewing Medical Images**
  - Addressing all aspects related to handheld image viewing
  - Emphasis on guidelines for practitioners and physicists performing clinical tasks
  - Medical physics perspective
- **Will coordinate activities with MIWG going forward**
- **Please contact Aldo Badano Aldo.Badano@fda.hhs.gov if you would like more information about this TG**

PROBLEMS STATEMENTS

- **Mobile display devices vary significantly with regard to**
  - Image quality
  - Color rendering characteristics
- **No standard color image data processing pipeline across mobile devices**
- **Display and platform technology changes rapidly**
  - Engineering trade offs do not always favor image and color quality and consistency
  - Especially true for mass production – non specialty displays
- **No standard target color rendering condition defined for display modalities used in medical applications**
- **The result:**
  - The same digital data displays differently on different devices
  - Image and color quality is poorly defined and controlled

X-RITE COLORTRUE SOLUTION

1. **Measure and profile the display**
   - Display standard test colors and measure each with a colorimeter
   - Calculate profile
   - Store profile
2. **Apply profile based on calibration and profile data to on-screen graphics using CPU or GPU**
   - Use embedded or assumed (sRGB) input profile
   - Combine with Display profile to get 3-D color transform
   - Apply color transform as image is rendered to the display

- **Resulting image that displays as intended in the input profile**
- **Different workflow than that used for desktop solutions**
- **Step 2 is application dependent**
  - Can be implemented in the ColorTrue image display function
  - Can be implemented in another app (such as a DICOM viewer) that implement the ColorTrue SDK to render the colors (ColorTrue Aware)

NEXT STEPS

- **Determine requirements**
  - Taxonomy of uses cases
  - Reproduction Aims
  - Calibration enough?
    - Calibration and characterization both needed?
  - Ambient/stray light compensation required?
  - Dynamic controls to be defeated?
- **Quantify “out of box” mobile display variability**
- **Determine architecture**
  - Server based
  - Client based
  - In-app
  - In-OS
- **Try concept proof using ColorTRUE solution**
- **Interested parties and results**
  - Contact amasia@xrite.com

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COLOR MANAGEMENT FOR MOBILE DEVICES

AGENDA

- Why is color management needed on mobile devices?
- X-Rite's Strategy
- Introducing X-Rite ColorTRUE
- SDK & Technology

TABLET BOOM

Tablets are here to stay!

- Q4 2013 -> First time tablets out sold PCs
- Portability, cost, ease of use factors is making use ubiquitous across wide ranges of medical applications

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CURRENT STATE

Mobile platforms are not well equipped for accurate and consistent color

- Wide range of display technologies, manufacturing standards
- No way to compensate for changes-over-time
- No system level color management in iOS or Android
  - Every image/color assumed sRGB
  - No way to share profiles across mobile apps

Customers want to use their tablets everywhere!

- No controlled lighting conditions
  (on location of shoot, on train, in coffee shop, etc.)
- Ambient lighting and display brightness affect user perception of color and contrast

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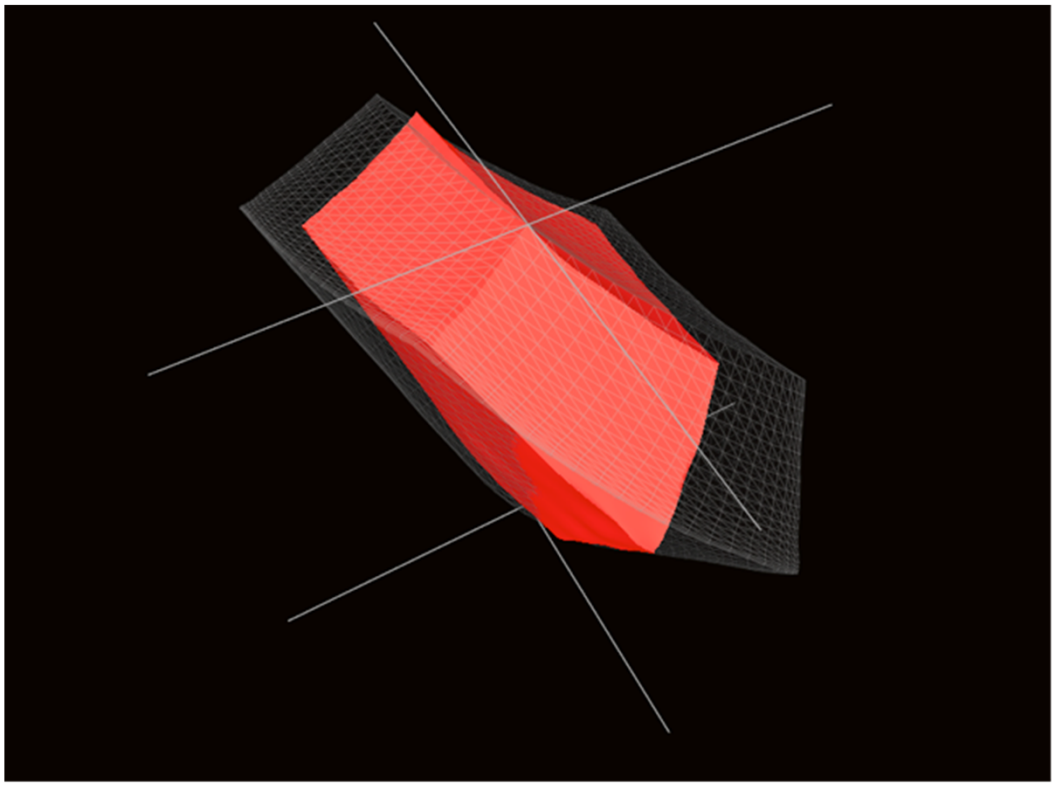
iPad Mini vs sRGB

iPad Mini

sRGB



- Gamut of iPad Mini is smaller than sRGB
- Native white point of iPad Mini is around 7500K
- Native gamma of iPad Mini is higher than sRGB

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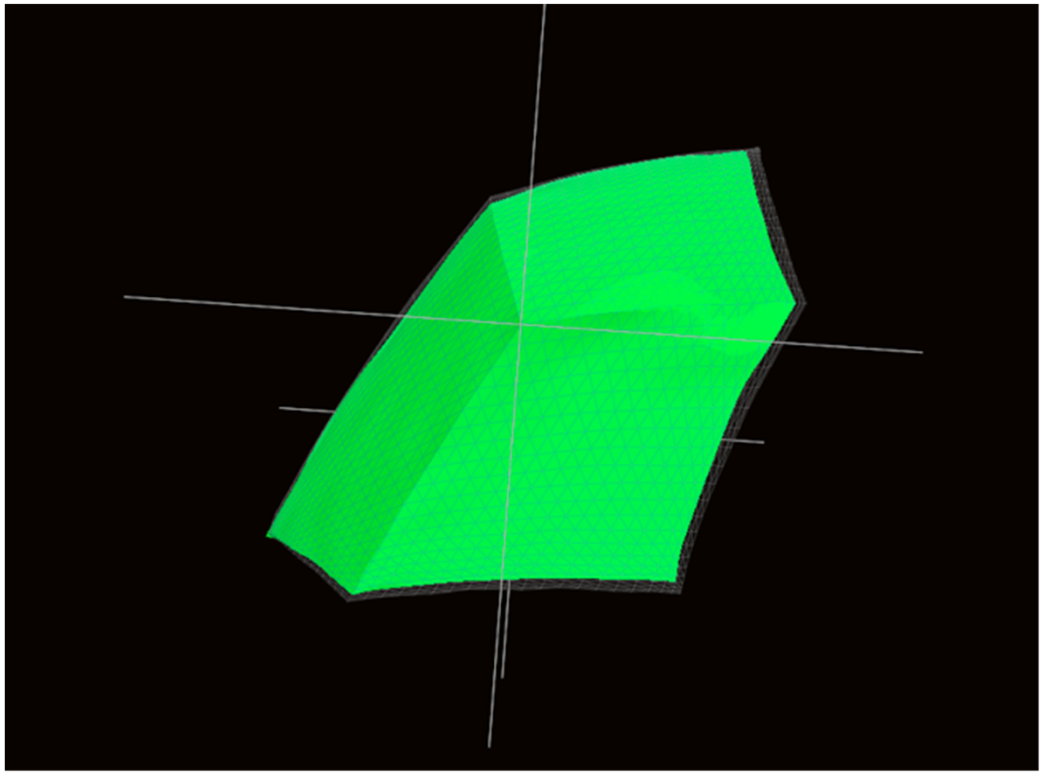
iPad3 vs sRGB

iPad 3

sRGB



- Gamut of iPad 3 is close to sRGB
- Native white point still around 7500K
- Native gamma still higher than sRGB

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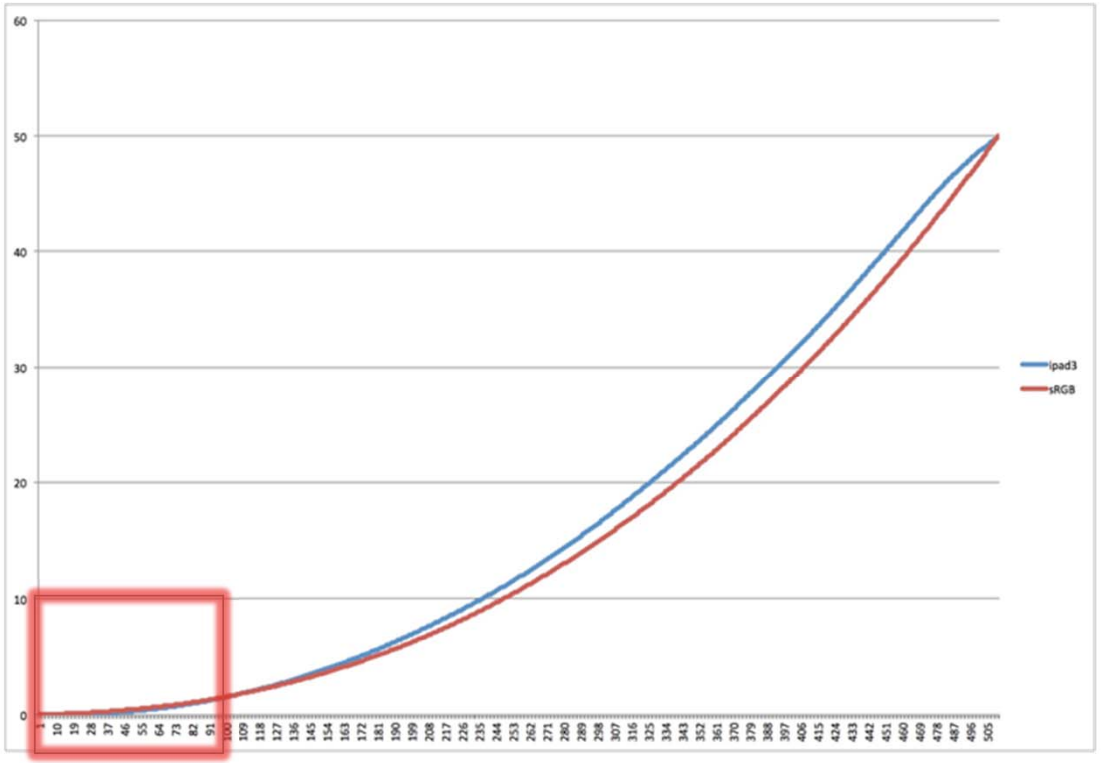
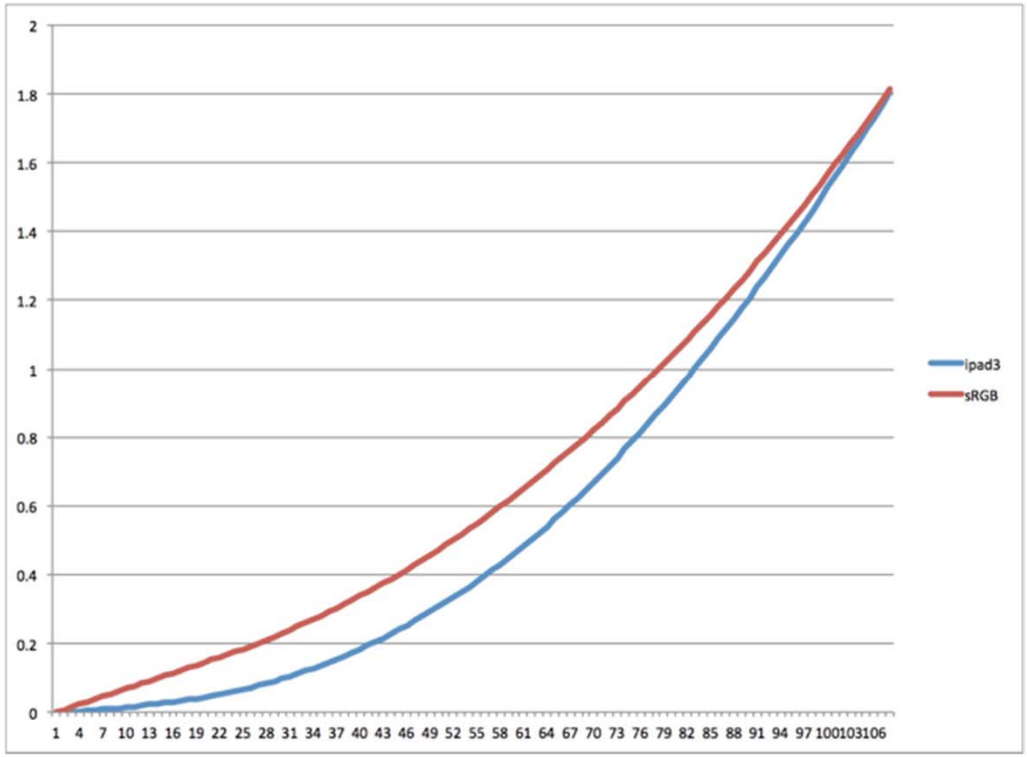
iPad3 vs sRGB (Gamma)



- iPad gamma steeper than sRGB -> more contrast
- Shadow region of iPad (highlighted) -> loss of detail

iPad3 vs sRGB (Shadows)



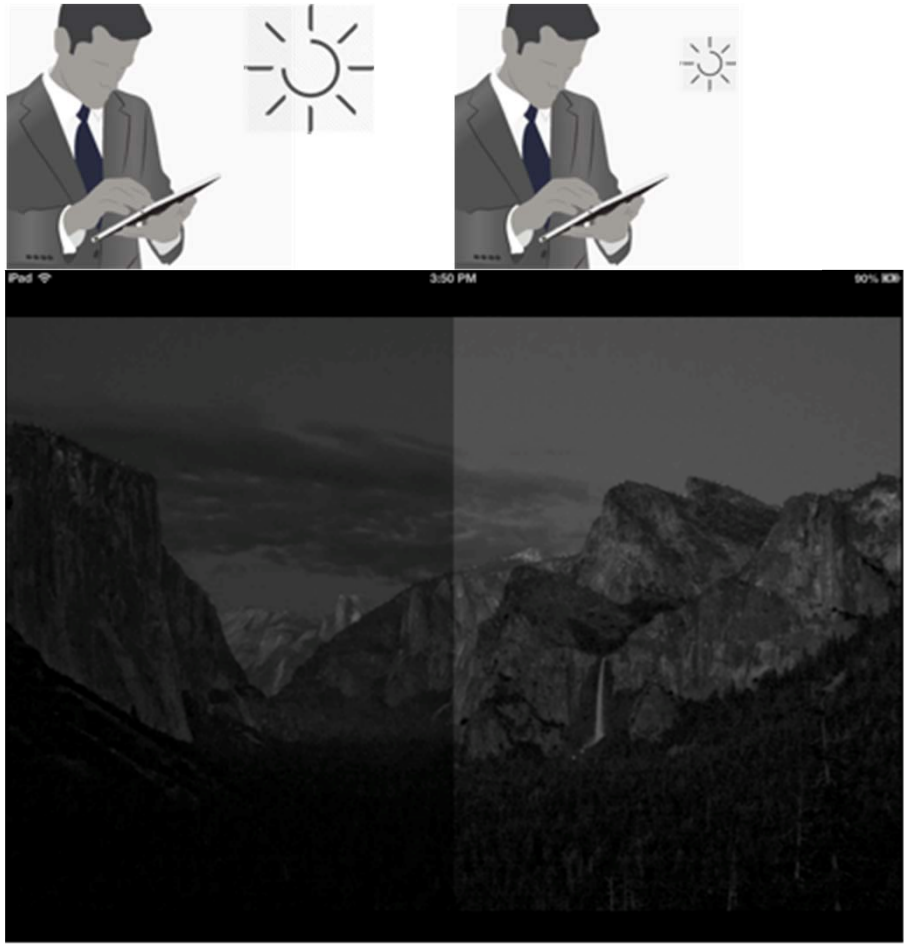
- Close up view of shadow region reveals loss of detail

TABLET MOBILITY - NEW COLOR MANAGEMENT CHALLENGE

AFFECTS OF DISPLAY BRIGHTNESS & AMBIENT LIGHTING

DECREASE in display brightness OR INCREASE in ambient lighting:

- Color saturation is “lower”
- Contrast & shadow detail are “less”



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X-RITE APPROACH

- **Provide CMM and profile management infrastructure on mobile platforms in form of Apps and SDK**
- **Workflow based on**
  - **Image input profile/display output profile 3-D color mapping – not on display calibration**
  - **Render-time CMM for 3-D color transform to present image for viewing as intended by input profile**
- **X-Rite provides free display profile generation app: ColorTRUE**
  - App measures and builds mobile display profiles and stores them in X-Rite Cloud server or locally on the tablet
  - Simple color managed image viewer also inside app
  - Viewer uses display (output) profile and embedded (or assumed sRGB) input profile
  - App branded and maintained by X-Rite
- **X-Rite provides SDK to 3rd party app developers**
  - Profile retrieval from X-Rite Cloud server
  - CMM for profile conversions

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SIMPLE PROOF-OF-CONCEPT CALIBRATED IMAGE VIEWING

1. Prepare medical images as JPEG or other common picture format
2. Load images into tablet Gallery
3. Install free ColorTRUE app
4. Run ColorTRUE app
5. View medical images as sRGB on calibrated device with built in toggle between “calibrated” and “uncalibrated”
6. Embed profile into image that includes DICOM tonal curve
7. Repeat 2, 5 for DICOM calibration

More at:

http://www.xrite.com/colortrue

INTEGRATION INTO TARGETED MEDICAL APPS

1. Get ColorTRUE SDK from X-Rite
2. Create input reference profile
3. Integrate color management into target app to make it “ColorTRUE Aware”
4. Install free ColorTRUE app
5. Run ColorTRUE app to create profile
6. Run target app

More at:

http://www.xrite.com/colortrueSDK